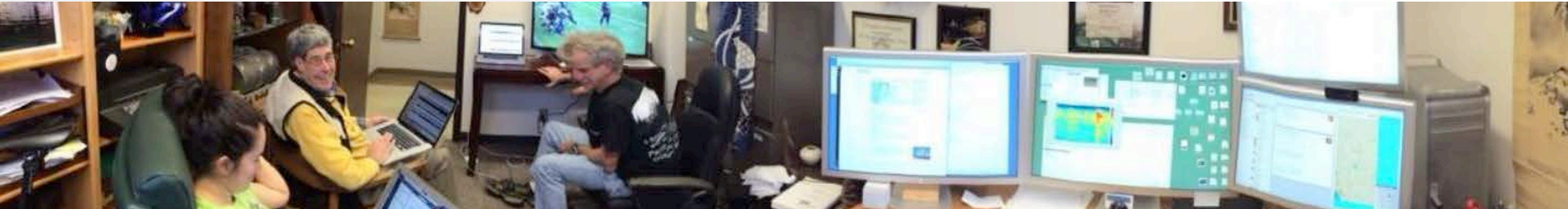
A TALE OF THREE SEATTLE TEMBLORS:
One Big, One Deep, and One Direct Hit

John Vidale
Professor of Earth and Space Sciences
State of Washington Seismologist

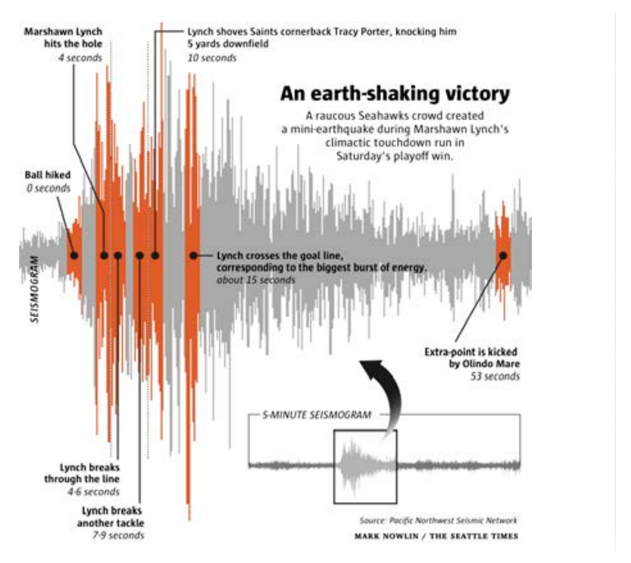
Talk outline

- Weird science
- Earthquake hazard in the Pacific Northwest
- The Pacific Northwest Seismic Network
- The M9 project / The New Yorker article
- Earthquake early warning for the West Coast



Most Famous Work

- Discovery of BeastQuake in 2011
- 2013, 2104 CenturyLink installations


Marshawn Lynch hits the hole 4 seconds
Lynch shoves Saints cornerback Tracy Porter, knocking him 5 yards downfield 10 seconds
An earth-shaking victory
A raucous Seahawks crowd created a mini-earthquake during Marshawn Lynch's climactic touchdown run in Saturday's playoff win.
Ball hiked 0 seconds
SEISMOGRAM
Lynch crosses the goal line, corresponding to the biggest burst of energy. about 15 seconds
Extra-point is kicked by Olindo Mare 53 seconds
5-MINUTE SEISMOGRAM
Lynch breaks through the line 4-6 seconds
Lynch breaks another tackle 7-9 seconds
Source: Pacific Northwest Seismic Network
MARK NOWLIN / THE SEATTLE TIMES

iMUS

Charting unsteady slow slip over and underneath locked zone.

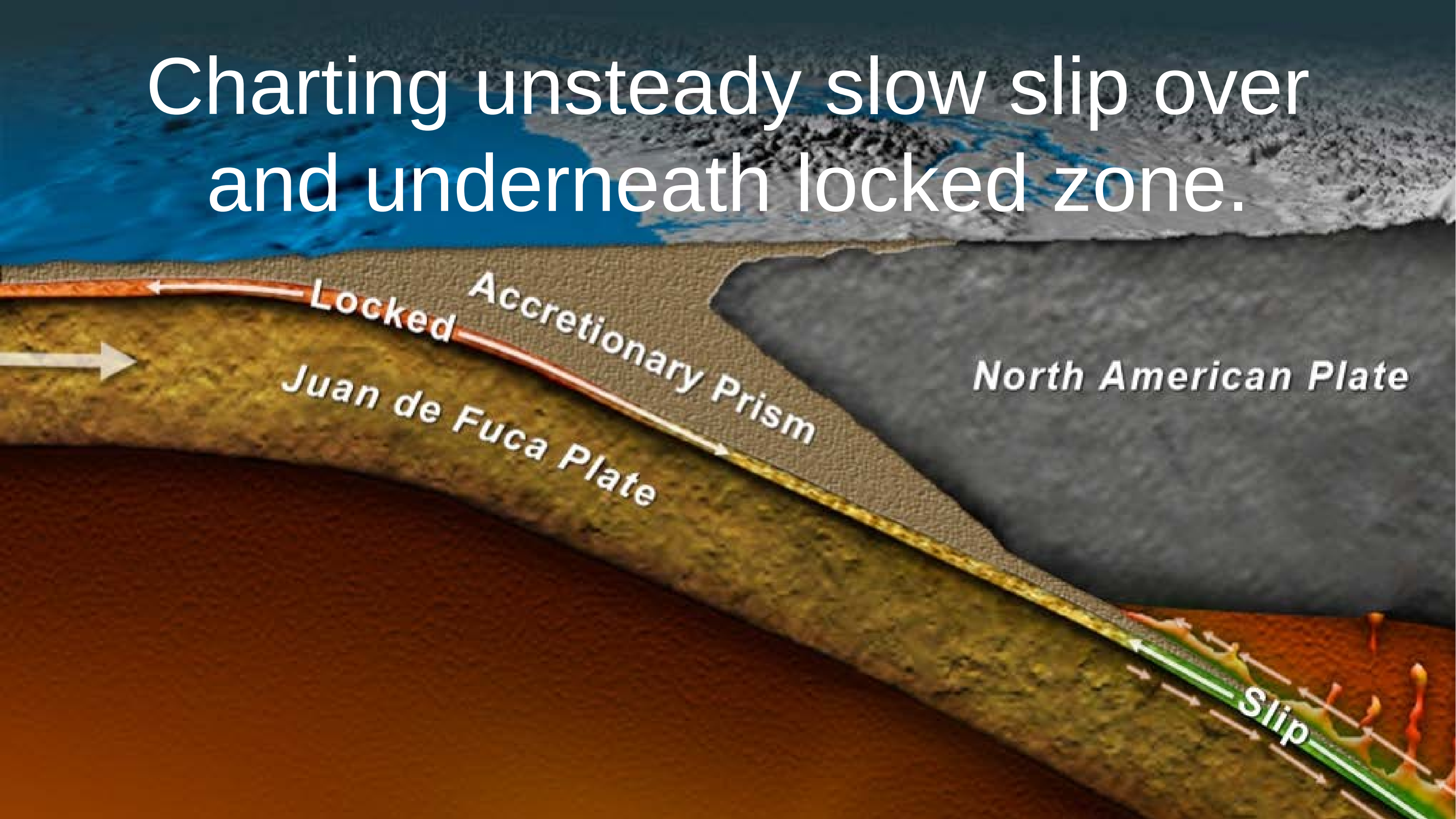
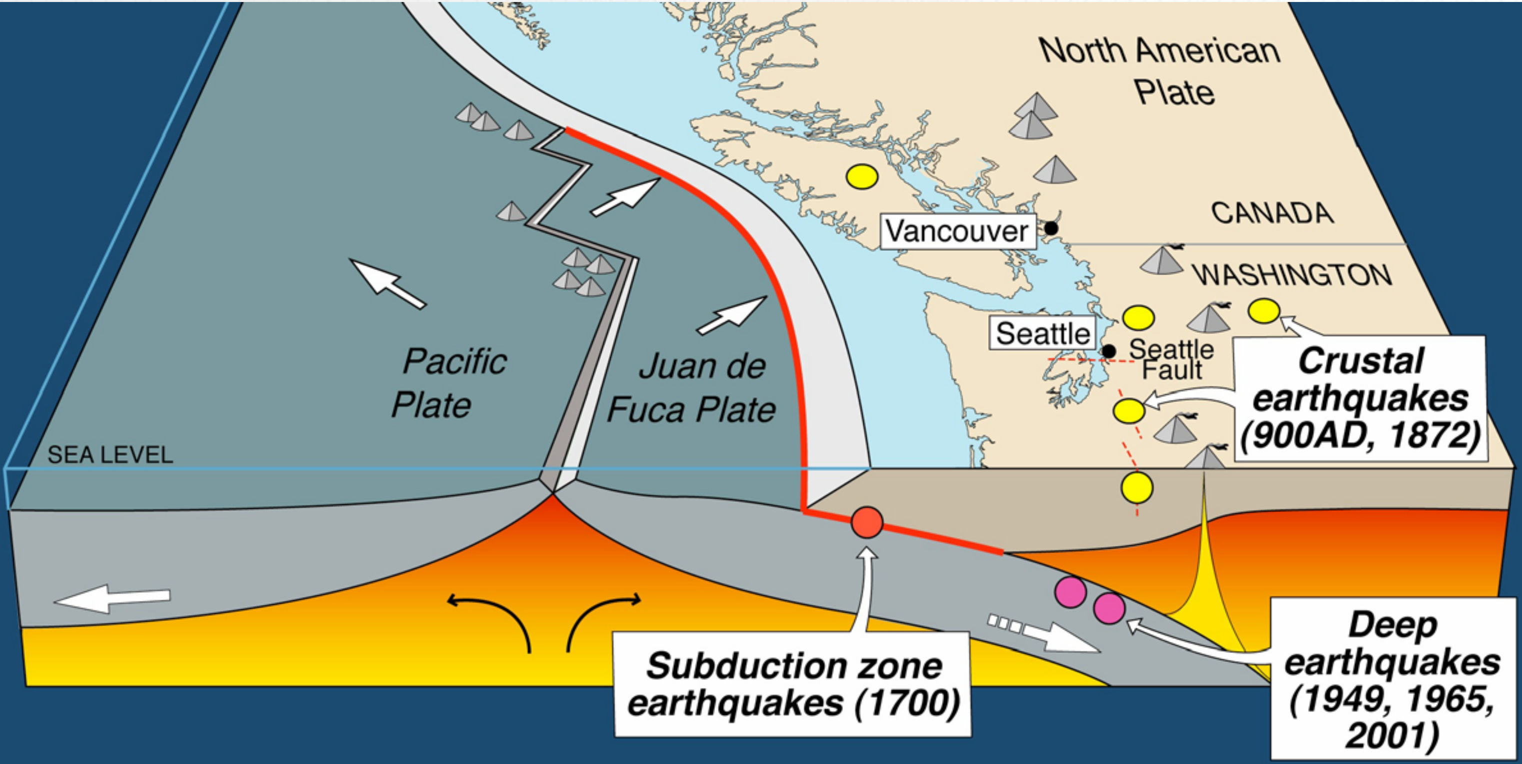
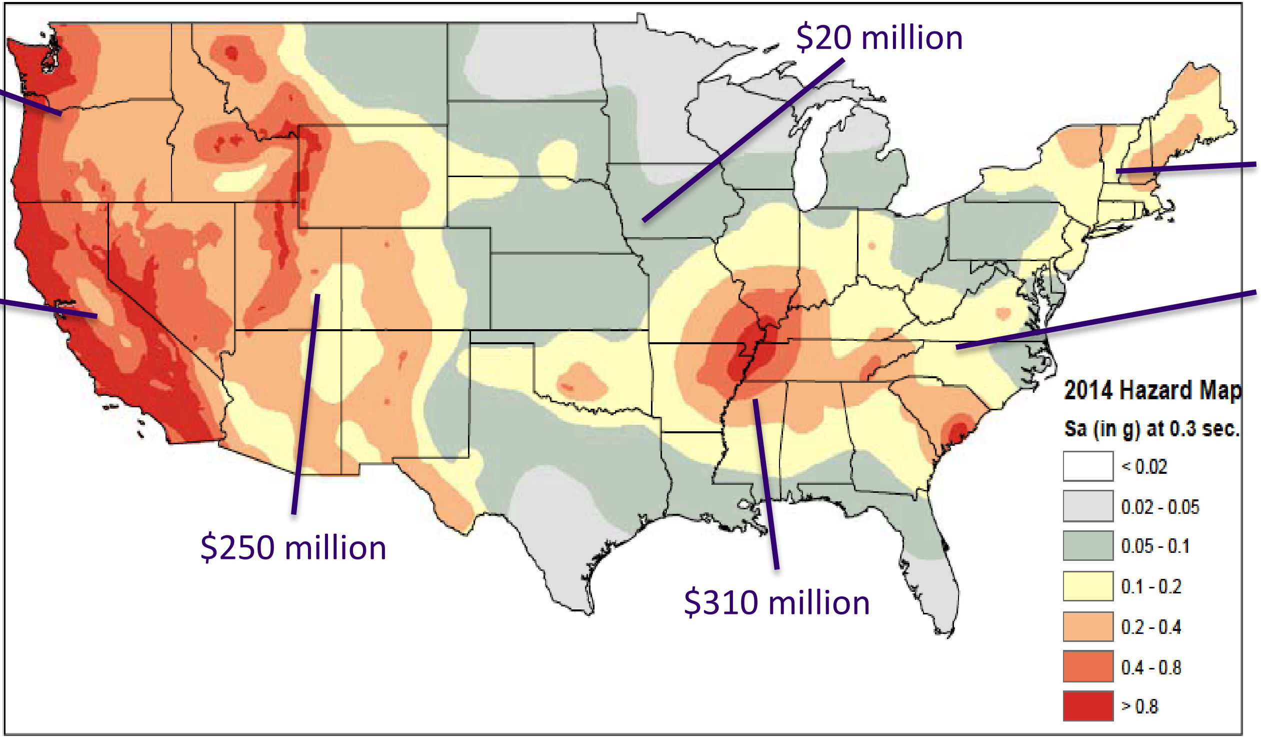


Plate Tectonic Setting

Juan de Fuca subducting under North America



Costs per Year of Seismic Hazards



$540 million
(WA & OR)

$3.1 billion
(CA)

$250 million

$20 million

$310 million

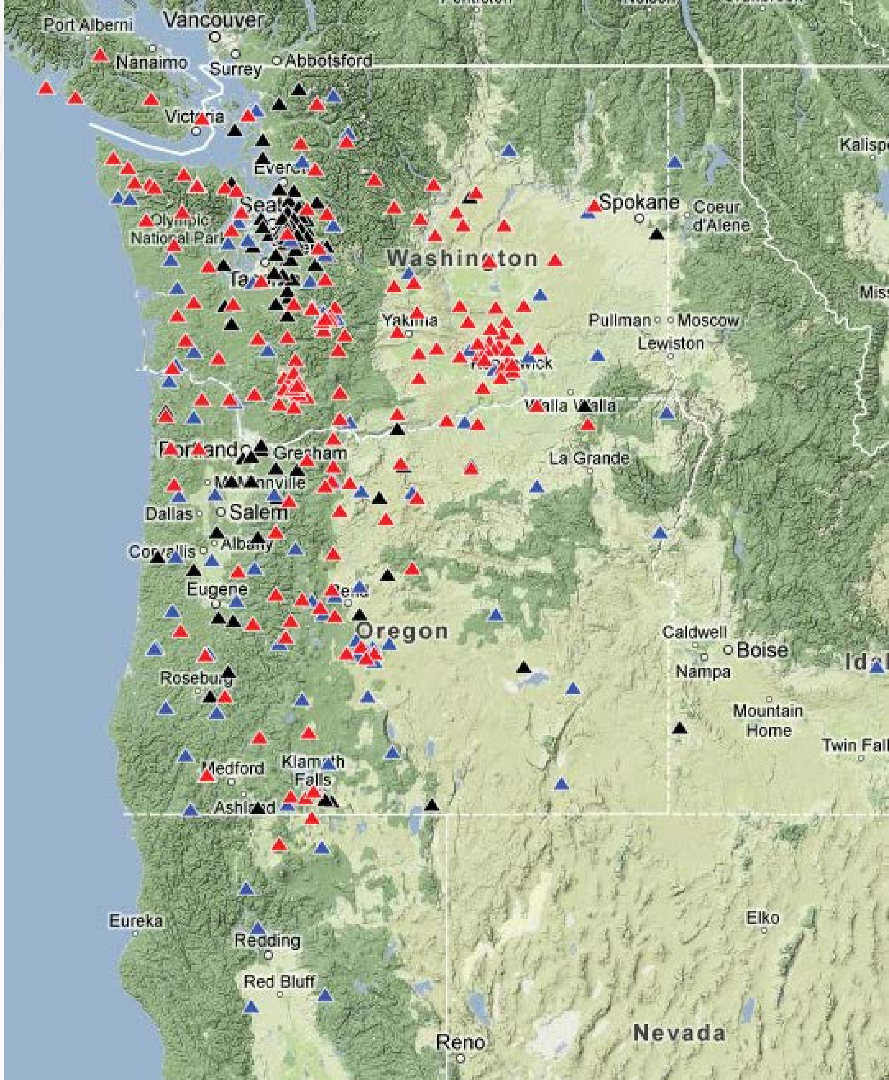
$130 million

$100 million

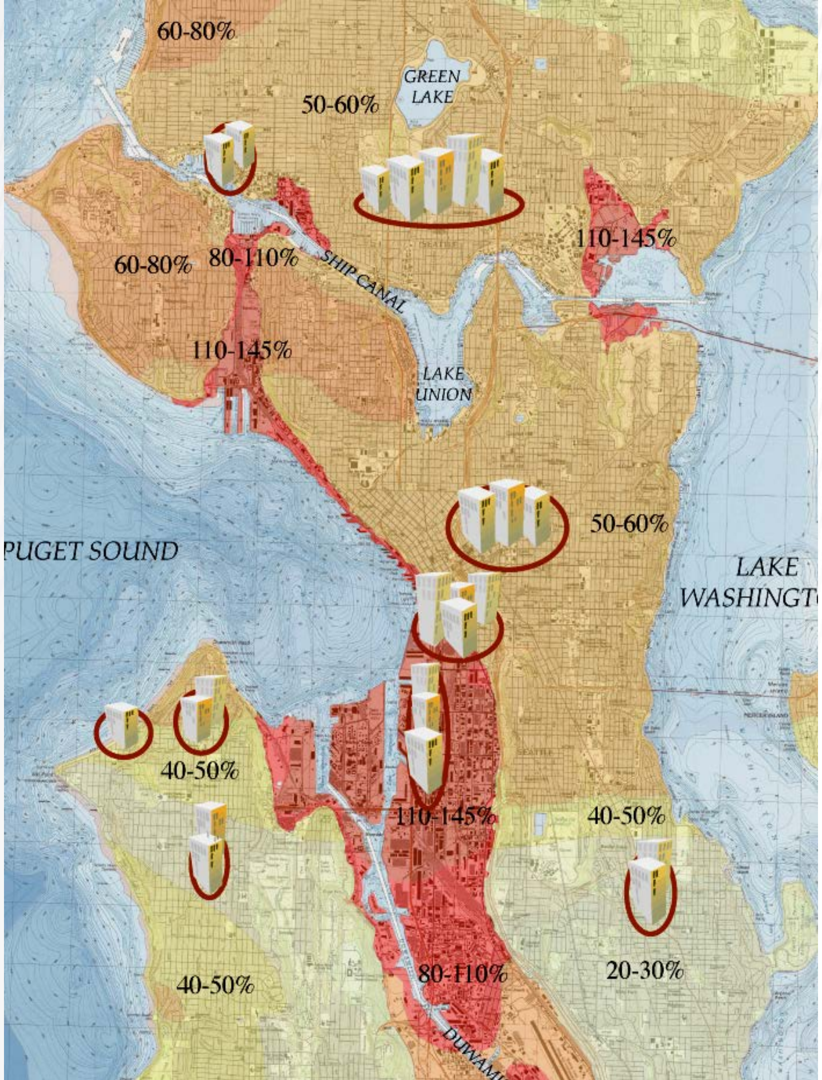
Pacific Northwest Seismic Network

PNSN
Pacific Northwest Seismic Network

400 seismometers of several types.

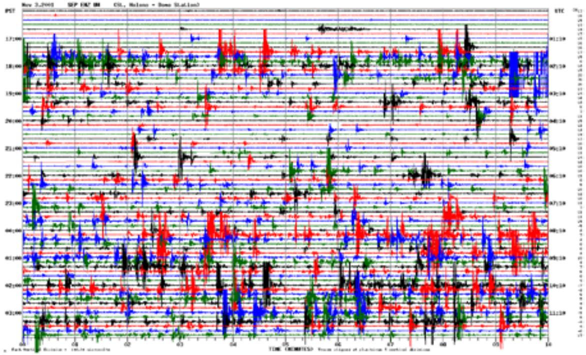


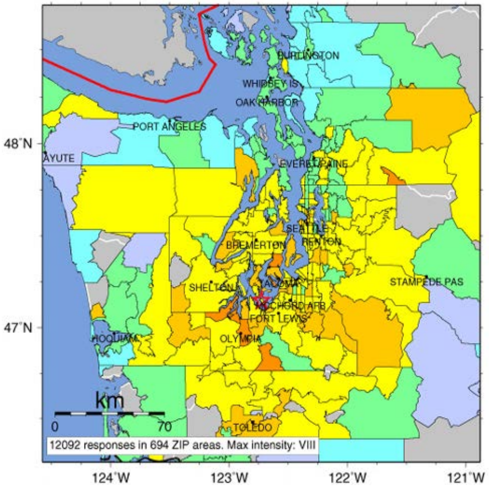
Issues in Seattle



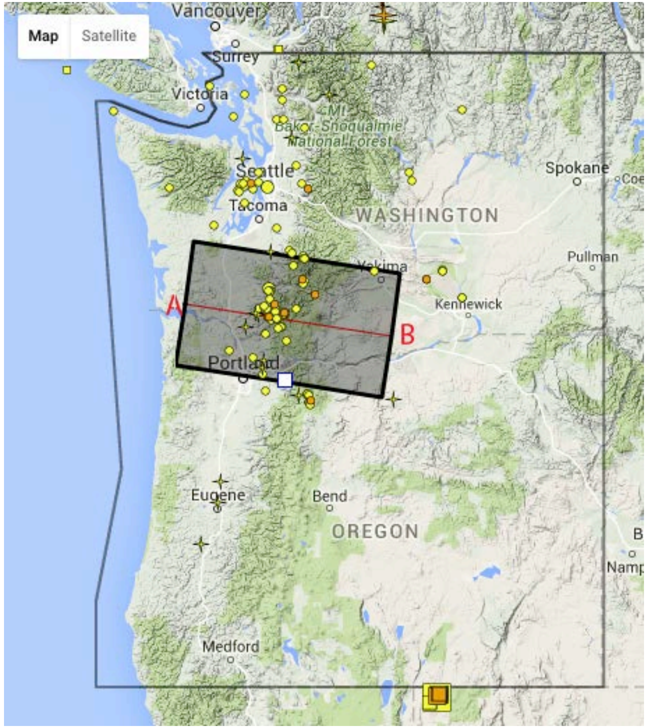
Products

- Seismograms
- *Did You Feel It* maps
- Recent Earthquakes



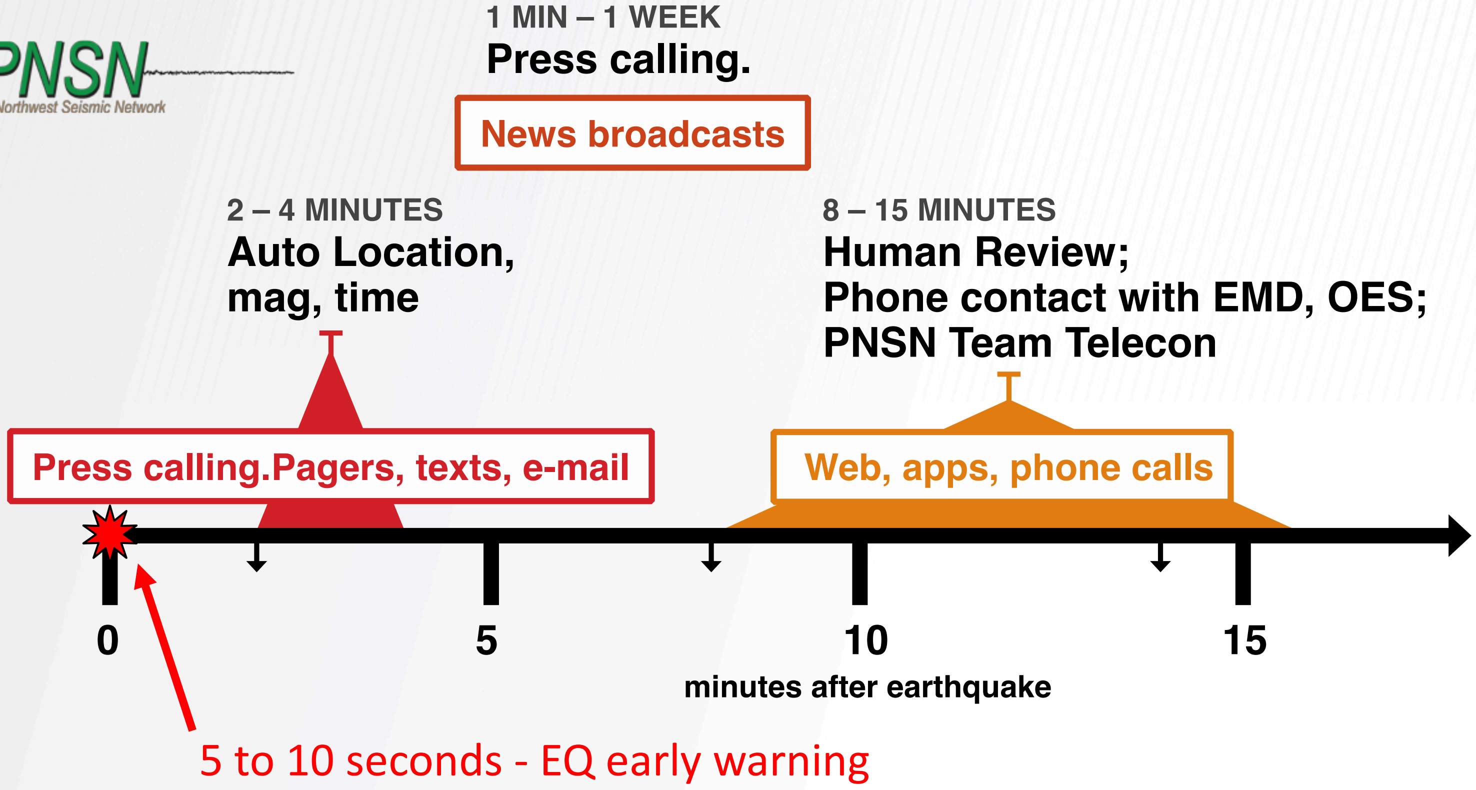


12092 responses in 694 ZIP areas. Max intensity: VIII



Earthquake info timeline

PNSN
Pacific Northwest Seismic Network



1 MIN – 1 WEEK
Press calling.

News broadcasts

2 – 4 MINUTES
Auto Location, mag, time

Press calling.Pagers, texts, e-mail

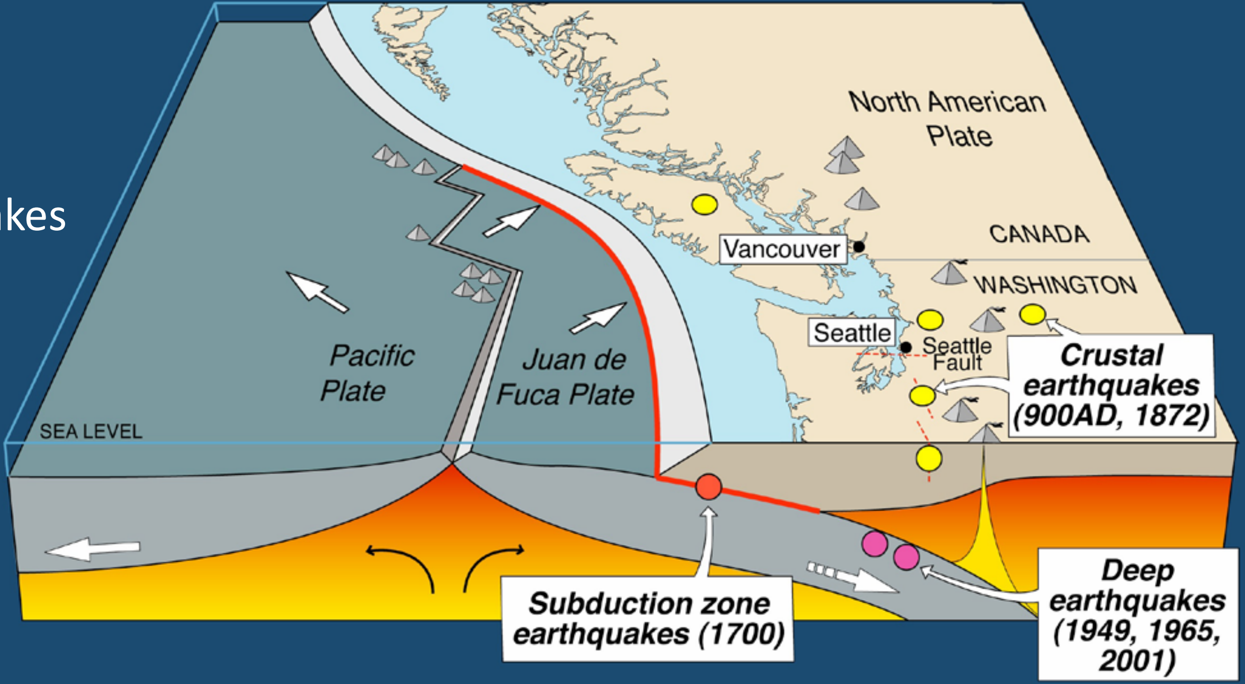
8 – 15 MINUTES
Human Review;
Phone contact with EMD, OES;
PNSN Team Telecon

Web, apps, phone calls

5 to 10 seconds - EQ early warning

Three Earthquakes Threats

1. Crustal Earthquakes
2. Deep Earthquakes
3. Subduction Zone Earthquakes



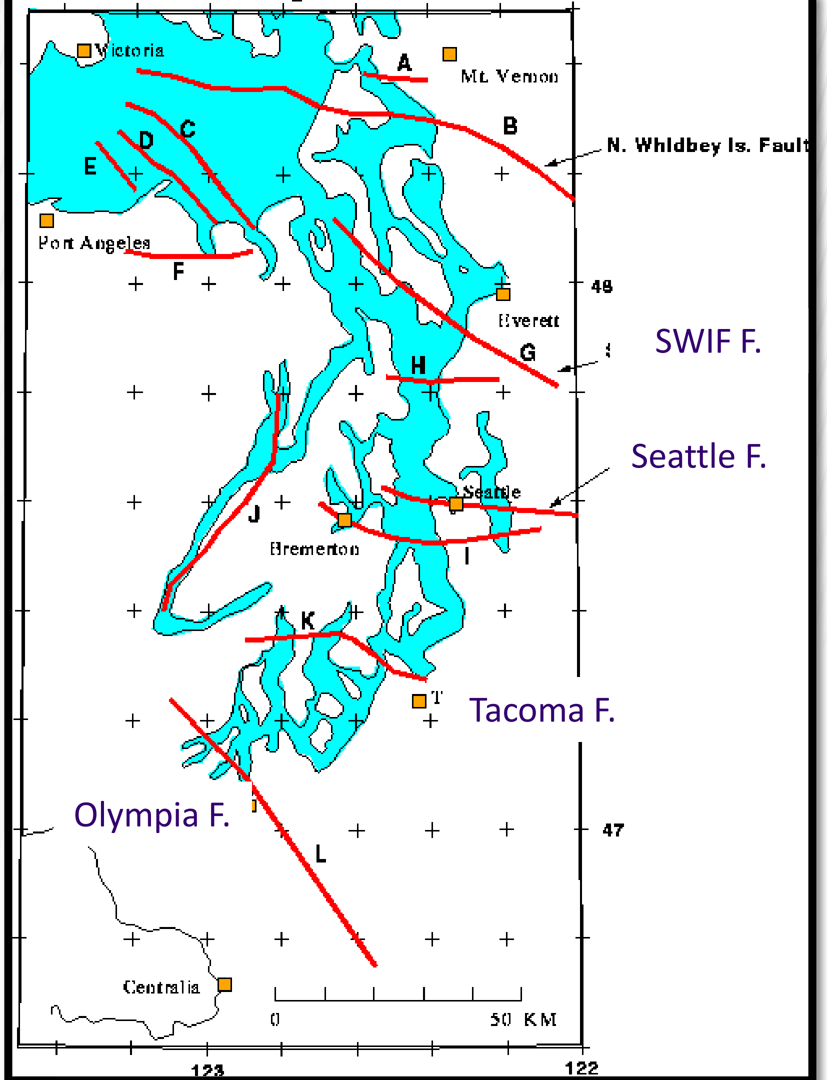
Crustal earthquakes (900AD, 1872)

Subduction zone earthquakes (1700)

Deep earthquakes (1949, 1965, 2001)

CRUSTAL EARTHQUAKES

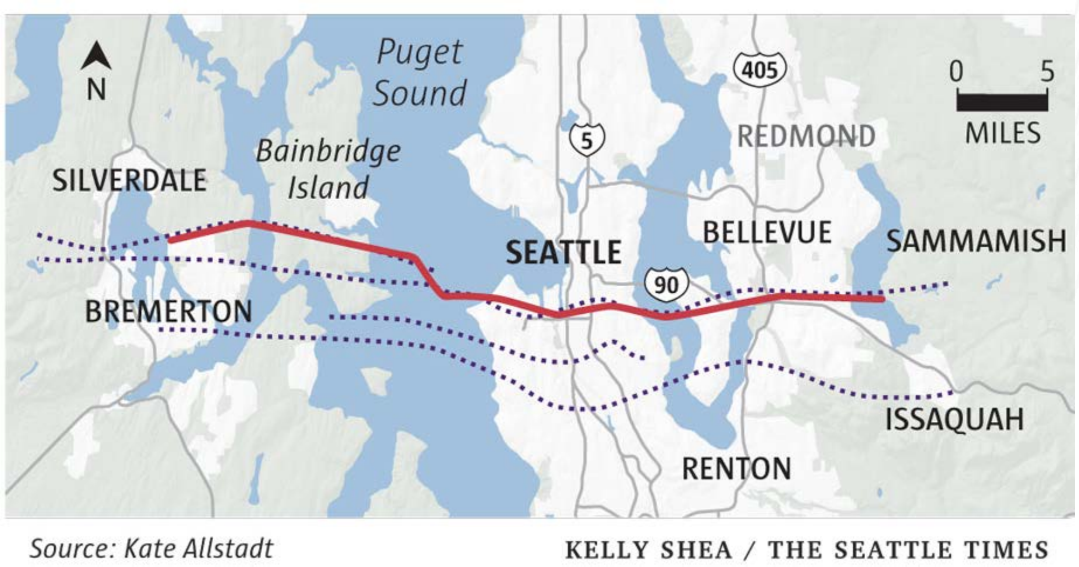
Major Fault Zones in Puget Sound



CRUSTAL EARTHQUAKES

900 AD M7.2 earthquake

DIRECT HIT ON SEATTLE

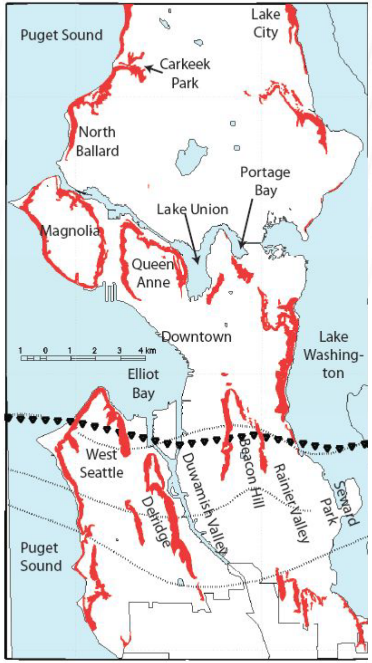


Source: Kate Allstadt

KELLY SHEA / THE SEATTLE TIMES

Map of Seattle Fault

EXAMPLE OF LANDSLIDES POSSIBLE

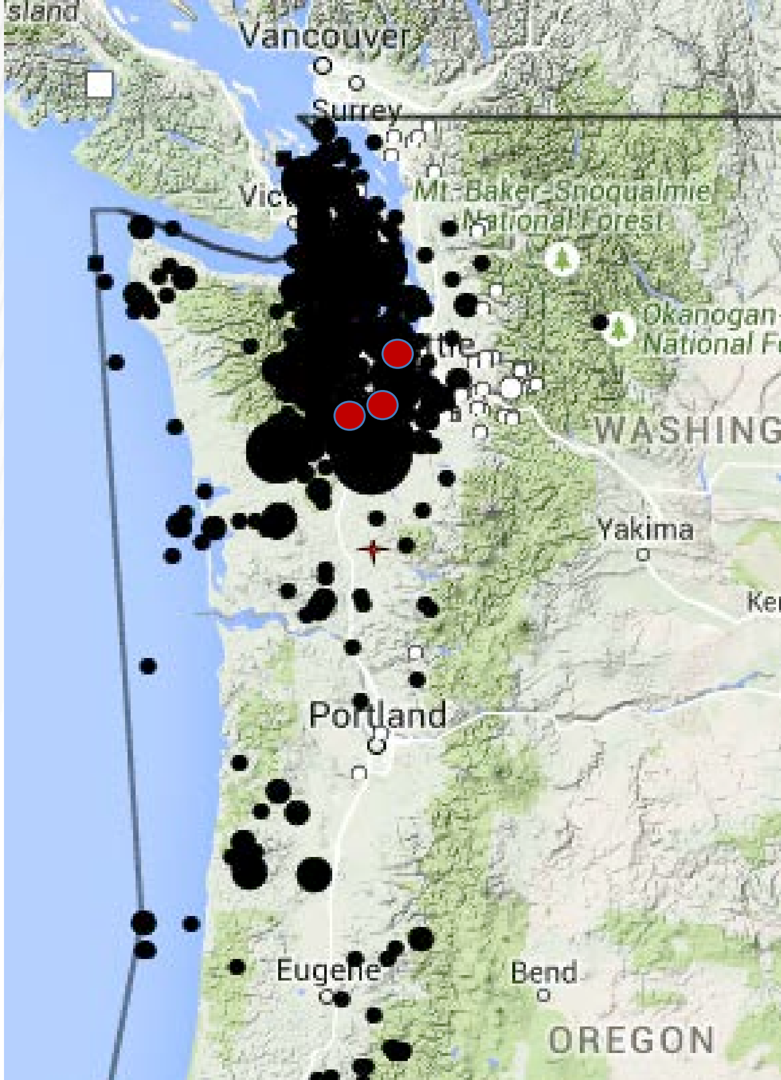


DEEP EARTHQUAKES

Deep Puget Sound Earthquakes

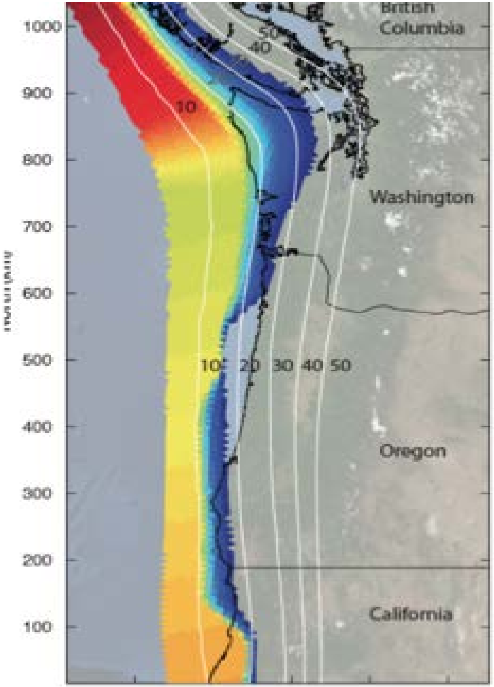
Three of M7 – 1949, 1965, 2001

Depth > 40 km since 2000

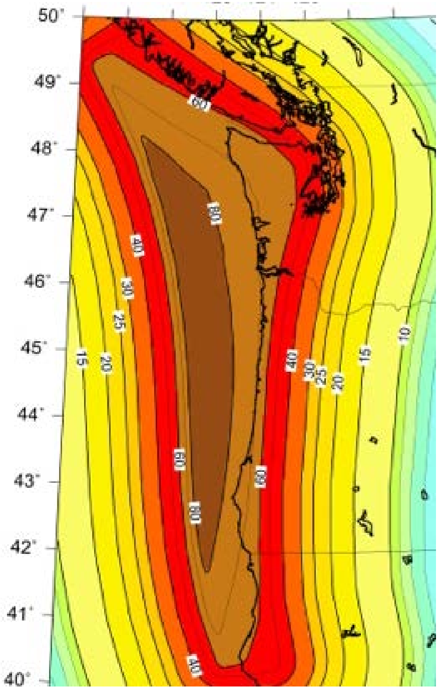


SUBDUCTION ZONE EARTHQUAKES

M9 fault rupture
(one model)



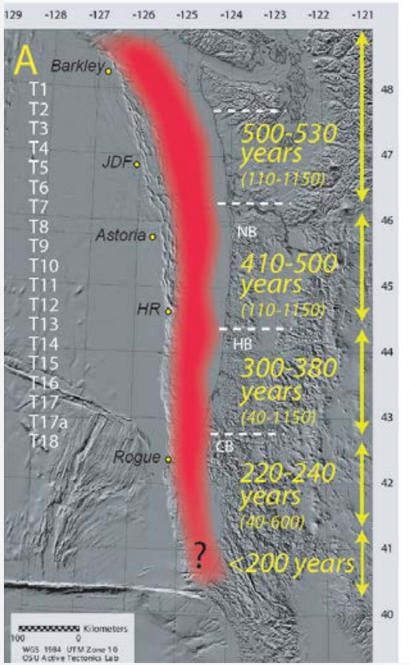
M9 shaking
(current simplistic estimate)



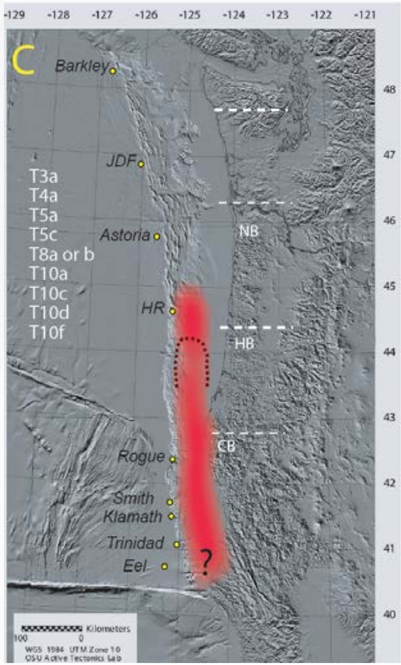
SUBDUCTION ZONE EARTHQUAKES

Last 10,000 years of M8+ earthquakes

20 M9 events

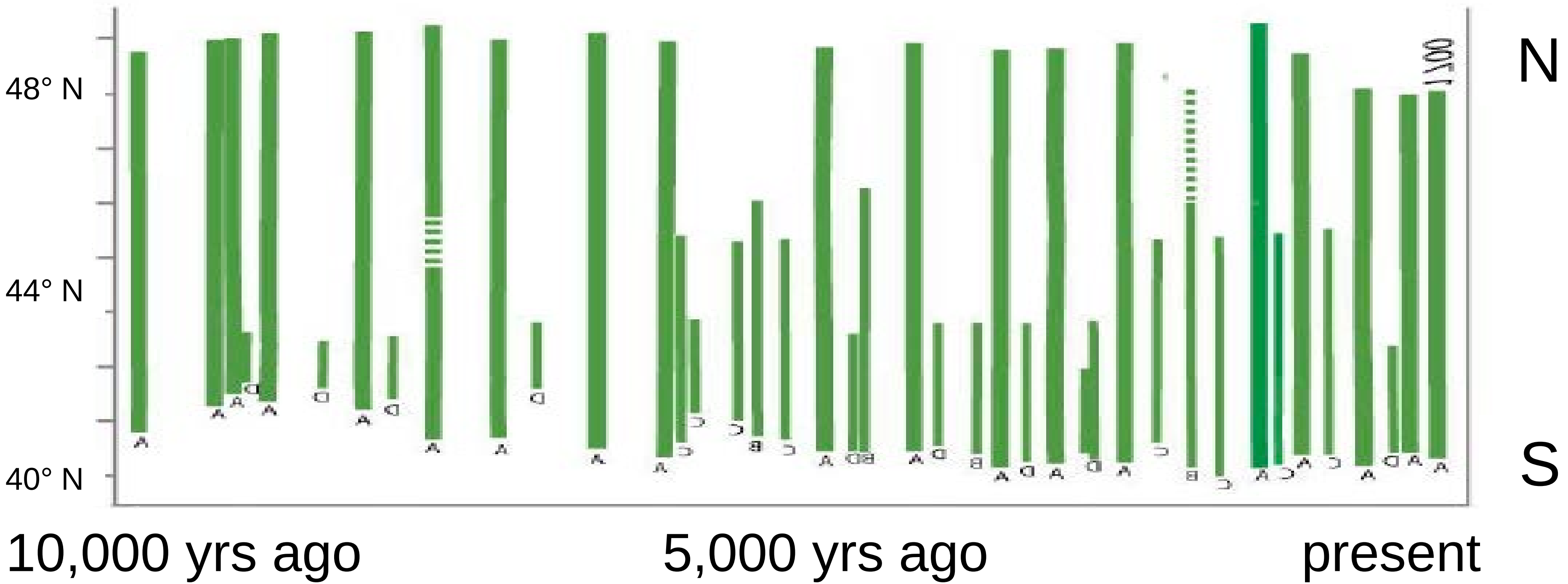


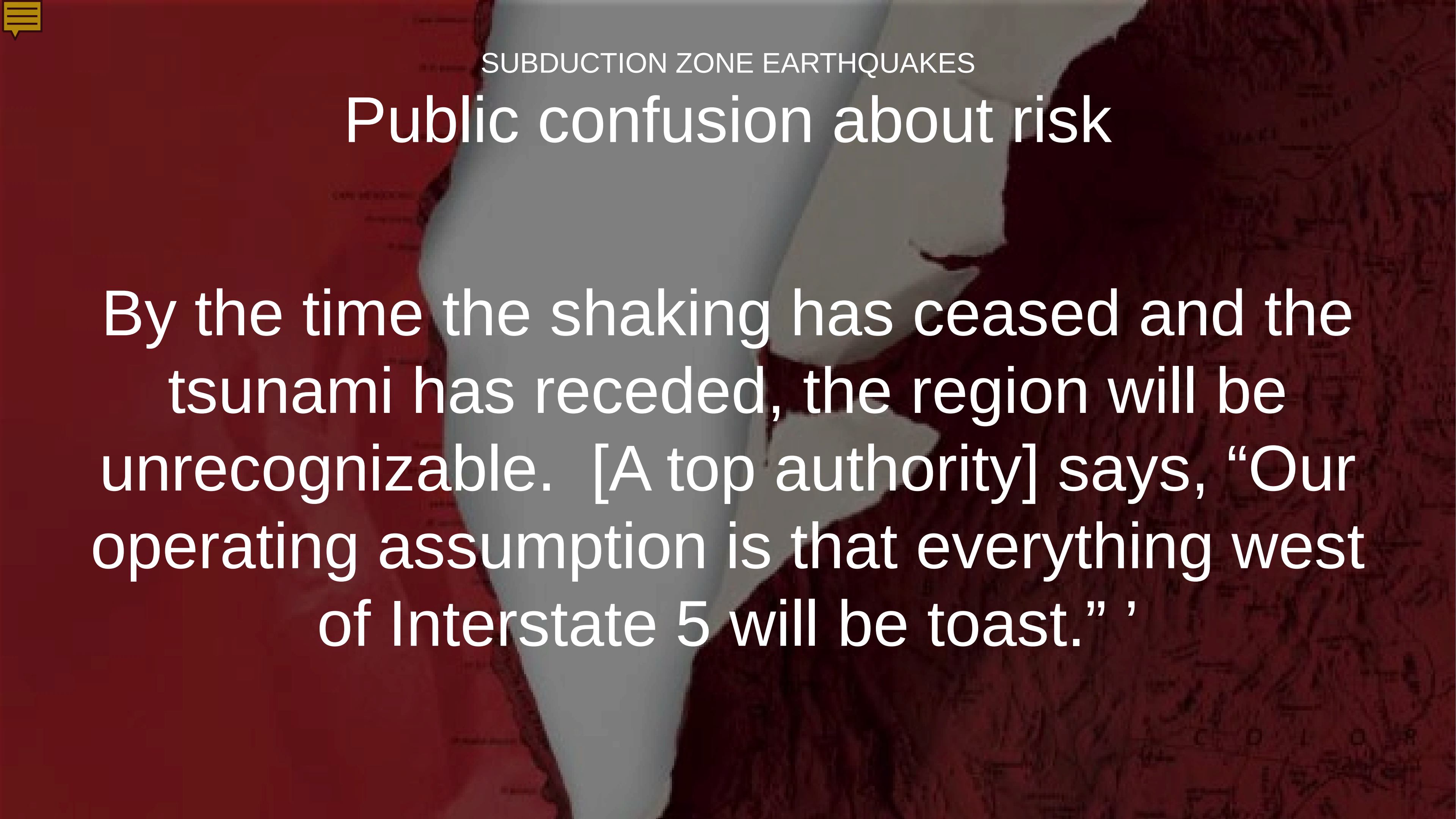
20 M8+ events



SUBDUCTION ZONE EARTHQUAKES

Last 10,000 years of M8+ earthquakes





SUBDUCTION ZONE EARTHQUAKES

Public confusion about risk

By the time the shaking has ceased and the tsunami has receded, the region will be unrecognizable. [A top authority] says, “Our operating assumption is that everything west of Interstate 5 will be toast.” ’

SUBDUCTION ZONE EARTHQUAKES

Public misinformation about risk

“Everything west of I-5 will be gone. Seattle, Tacoma, Olympia, Portland, Salem, 7 million people …, plus tourists.”

M9 Project
Cascadia Subduction Zone

- Fault Rupture Models and
- resulting Broadband Ground Motions
- Buildings and infrastructure
- Tsunamis
- Liquefaction
- Landslides

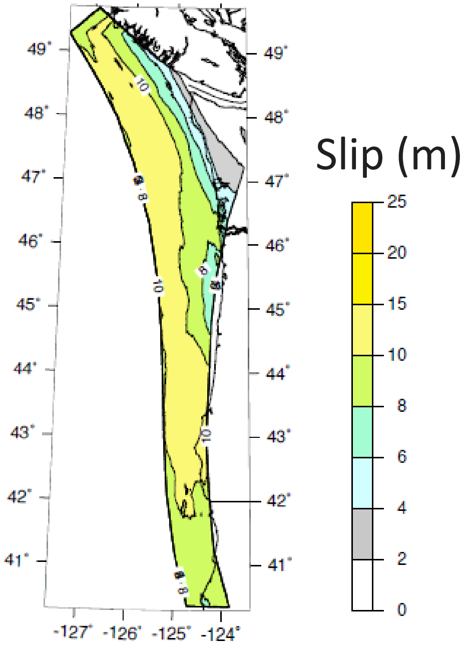
- Early Warnings – perceptions decisions and behaviors
- Interactive integrated risk analysis maps
- Education and outreach
- Community planning and enhanced resilience

Long Term Goals and Impacts

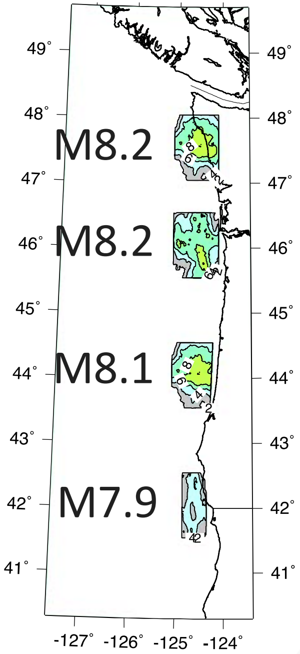
- Planning changes that lead to increased resilience
- Updated building codes and changes in engineering practice
- Effective early warnings
- Integrated into emergency response and decision-making
- Advance fundamental knowledge about extreme seismic events

Simulated Cascadia earthquake

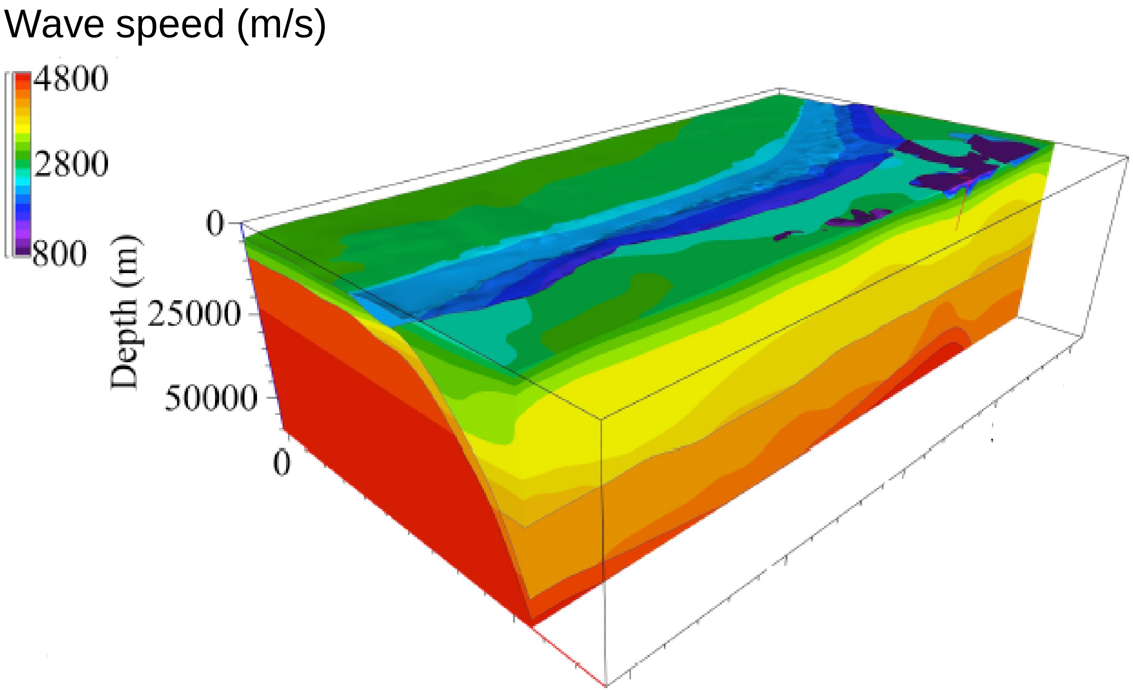
Smooth M9 background slip



plus pops

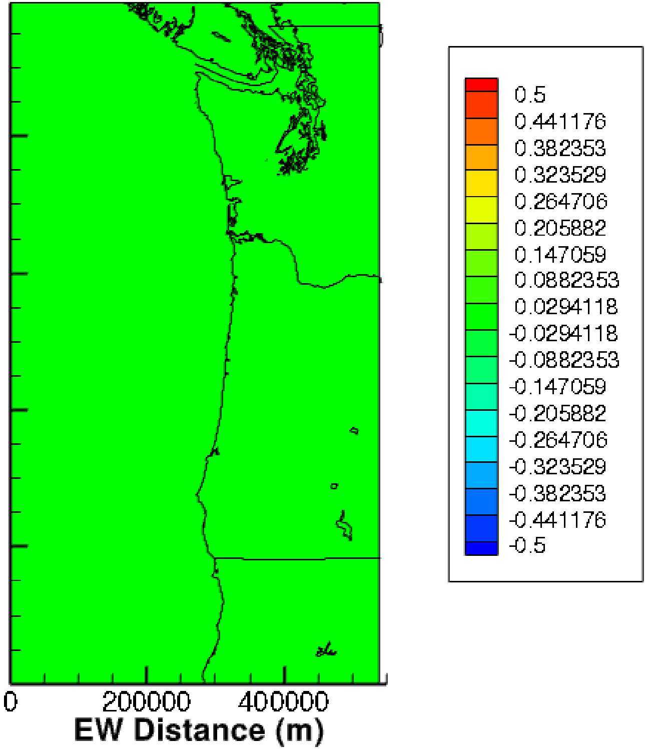


Geological computer model for Cascadia

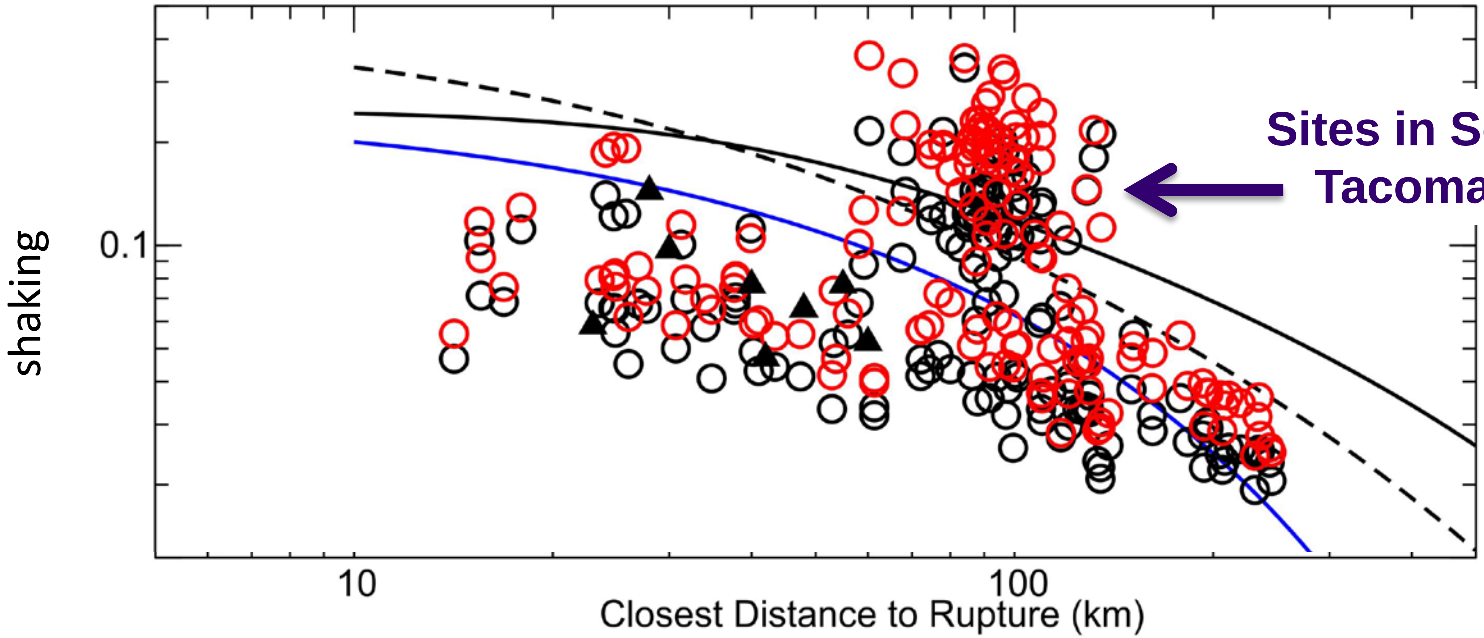


SUBDUCTION ZONE EARTHQUAKES

3-minute M9.0 simulation



Amplified M9 shaking



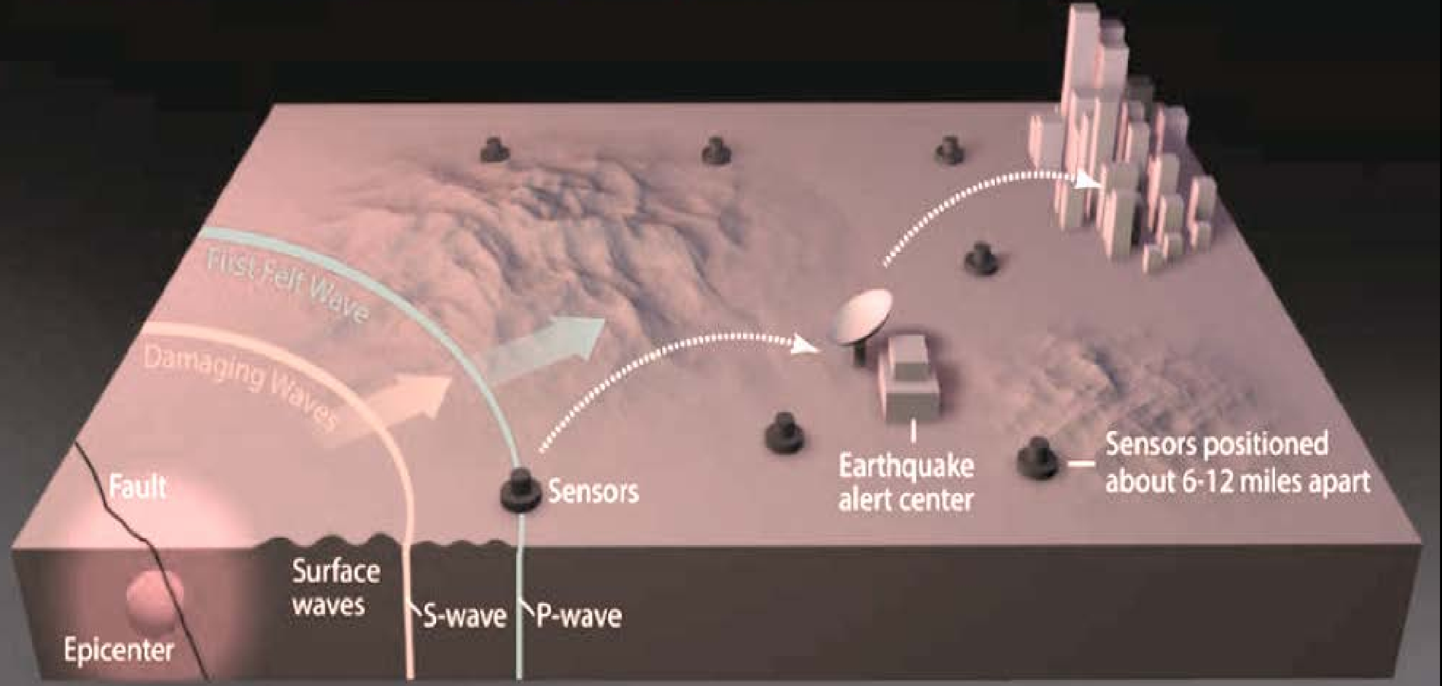
Sites in Seattle and Tacoma basins

Earthquake Early Warning Basics

1 In an earthquake, a rupturing fault sends out three different types of waves. The fast-moving P-wave is first to arrive, but the damage is caused by the slower S-waves and surface waves.

2 Sensors detect the P-wave and immediately transmit data to an earthquake alert center where the location and size of the quake are determined and updated as more data become available.

3 A message from the alert center is immediately transmitted to your computer or mobile phone, which calculates the expected intensity and arrival time of shaking at your location.



Earthquake Early Warning, considerations: $16M/yr for West Coast

- Earthquake early warning and fast response:
  - Slowing traffic, trains, airports
  - Hospitals, jump-starting emergency operation
  - Warning delicate industrial operations
  - Suspending computer operations
  - Personal situation awareness (and reassurance)

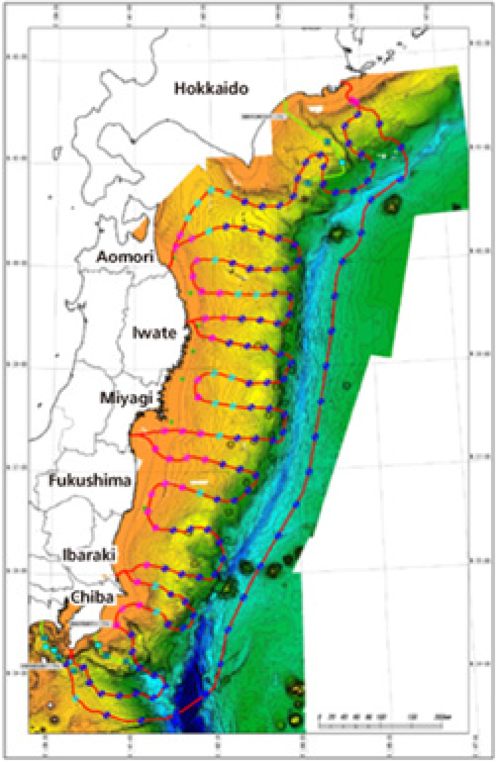
- Everybody that’s anybody is doing it:
  - Japan (~$1B), China (~$300M+), Mexico, Korea, Romania, Taiwan, Mongolia, are doing it now.

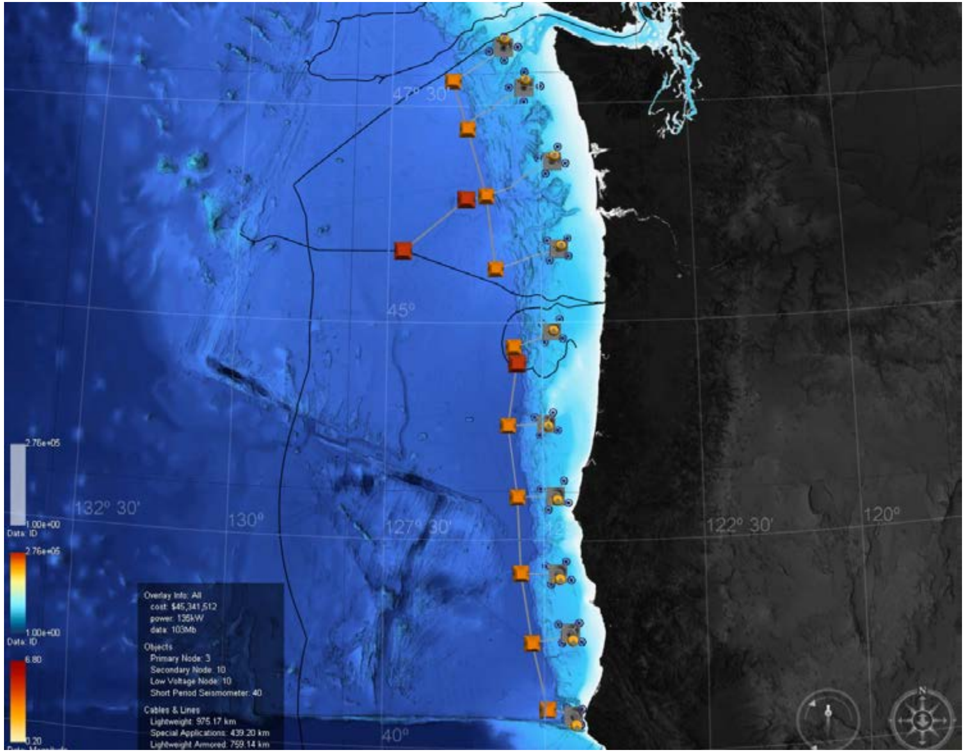
- It’s not hard:
  - Basic physics known for more than a century
  - Accurate results before chaos sets in
  - Much better performance during chaos

My day Thursday

Energy and Natural Resources Committee
SD-366
Dr. John V

Cabled offshore observatory?



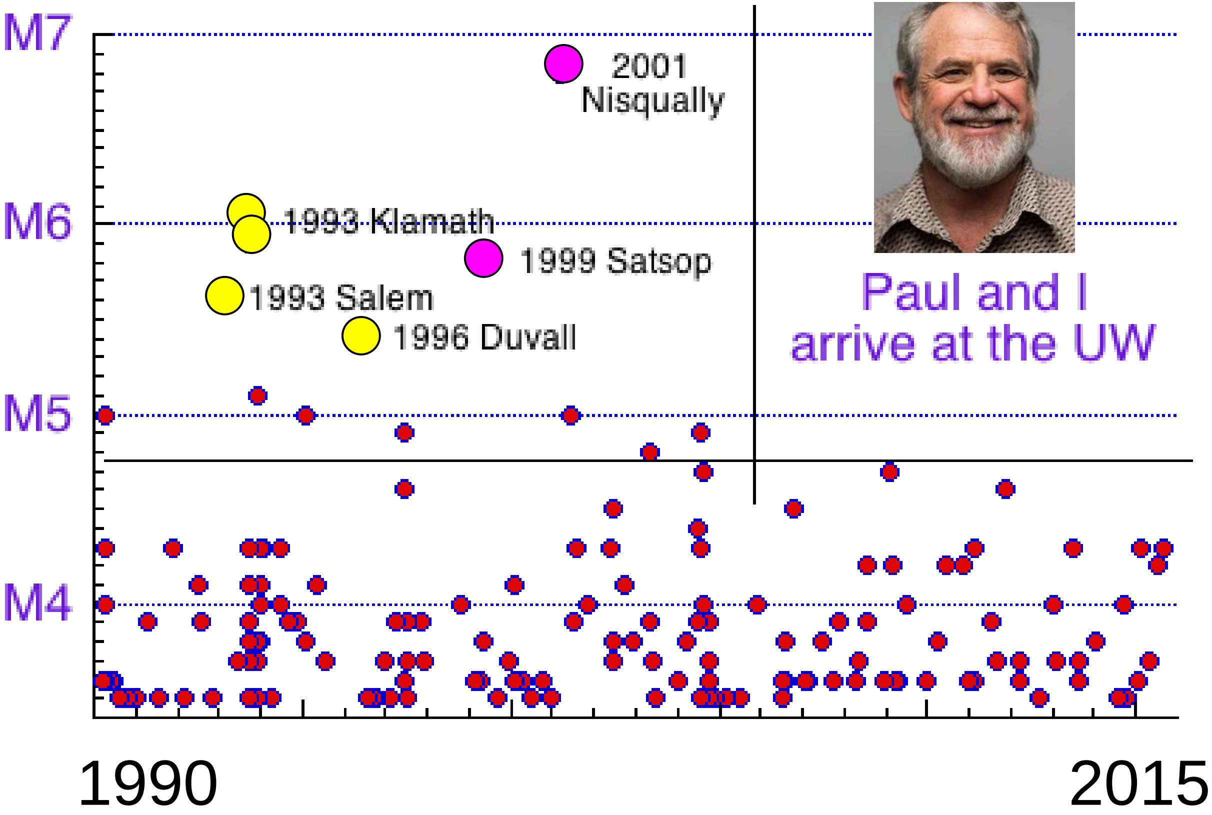


Overlay Info: All
cost: $45,341,512
power: 135kW
data: 103Mb

Objects
Primary Node: 3
Secondary Node: 10
Low Voltage Node: 10
Short Period Seismometer: 40

Cables & Lines
Lightweight: 975.17 km
Special Applications: 439.20 km
Lightweight Armored: 759.14 km

Timeline of earthquakes M > 3.5



Paul and I arrive at the UW